# Kinetic Theory of Gases

## Gas Laws

**2011**

**1. A perfect gas at $27^0C$ is heated at constant pressure so as to double its volume. The increase in temperature of the gas will be**

a) $600^0C$ b) $327^0C$ c) $54^0C$ d) $300^0C$

**2. Air inside a closed container is saturated with water vapour. The air pressure is p and the saturated vapour pressure of water is $\overline{p}$. If the mixture is compressed to one-half of its volume by maintaining temperature constant, the pressure becomes**

a) $2(p+\overline{p})$ b) $2p+\overline{p}$ c) $(p+\overline{p})/2$ d) $p+2\overline{p}$

**2010**

**3. If pressure of $CO_2$ (real gas) in a container is given by $p=\frac{RT}{2V-b}-\frac{9}{4b^2}$, then mass of the gas in container is**

a) 11J b) 22 J c) 33 J d) 44 J

**4. A closed vessel contains 8g of oxygen and 7g of nitrogen. The total pressure is 10 atm at a given temperature. If now oxygen is absorbed by introducing a suitable absorbent the pressure of the remaining gas (in atm) will be**

a) 2 b) 10 c) 4 d) 5

**5. Ideal gas and real gas have major difference of**

a) Phase Transition b) Temperature

c) Pressure d) None of these above

**2009**

**6. By what percentage should the pressure of a given mass of a gas be increased, so as to decrease its volume by 10% at a constant temperature?**

a) 5% b) 7.2% c) 12.5% d) 11.1%

**7. When a van der Wall's gas undergoes free expansion, then its temperature**

a) Decreases b) Increases

c) Does not change d) Depends upon the nature of the gas

**8. An electron tube was sealed off during manufacture at a pressure of** $1.2\times10^{-7}mm$ **of mercury at** $27^0C$**. Its volume is** $100cm^3$**. The number of molecules that remain in the tube is**

a) $2\times10^{16}$ b) $3\times10^{15}$ c) $3.89\times10^{11}$ d) $5\times10^{11}$

**2008**

**9. At** $10^0C$ **the value of the density of a fixed mass of an ideal gas divided by its pressure is x. At** $110^0C$ **this** ratio is

a) x b) $\frac{383}{283}x$ c) $\frac{10}{110}x$ d) $\frac{283}{383}x$

**10. A balloon contains** $500m^3$ **of He, at** $27^0C$ **and 1 atm pressure. The volume of He, at** $-3^0C$ **and 0.5 atm pressure will be**

a) $700m^3$ b) $900m^3$ c) $1000m^3$ d) $500m^3$

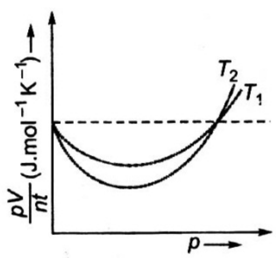
**11. The phenomenon of Brownian movement may be taken as evidence of**

a) Kinetic theory of matter b) EMT of radiation

c) Corpuscular theory of light d) Photoelectric phenomenon

**2007**

**12. The figure below shows the plot of** $\frac{pV}{nT}$**. Versus p for oxygen gas at two different temperatures**



**Read the following statements concerning the above curves**

**i) The dotted line corresponds to the 'ideal' gas behaviour**

**ii)** $T_1 > T_2$

**iii) The value of** $\frac{pV}{nT}$ **at the point where the curves meet on the y-axis is the same for all gases**

**Which of the above statements is true?**

a) i only b) i and ii only c) All of these d) None of these

**13. One litre of an ideal gas at** $27^0 C$ **is heated at a constant pressure to** $297^0 C$ **. Then, the final volume is approximately**

a) 1.2 L b) 1.9L c) 19L d) 2.4L

**2006**

**14. Two balloons are filled one with pure He gas and the other by air, respectively. If the pressure and temperature of these balloons are same then the number of molecules per unit volume is**

a) More in the He filled balloon b) Same in both balloons

c) More in air filled balloon d) In the ratio of 1: 4

**2005**

**15. Real gases obey ideal gas laws more closely at**

a) Low pressure and low temperature b) Low pressure and high temperature

c) High pressure and low temperature d) Low pressure and high temperature

**2004**

**16. the equation of state for 5 g of oxygen at a pressure p and temperature T, when occupying a volume V, will be**

a) pV = (5/32) RT b) pV = 5RT c) pV = (5/2) RT d) pV = (5/16) RT

**17. If a given mass of gas occupies a volume of 10cc at 1atm pressure and temperature $100^0 C$. What will be its volume at 4 atm pressure, the temperature being the same?**

a) 100 cc b) 400 cc c) 104 cc d) 2.5 cc

**18. Two gases of equal masses are in thermal equilibrium. If $p_a$ , $p_b$ and $V_a$, $V_b$ are their respective pressure and volumes, then which relation is true**

a) $2p_aV_a = p_bV_b$ b) $p_a \neq p_b, V_a \neq V_b$ c) $\frac{p_a}{V_a} = \frac{p_b}{V_b}$ d) $p_aV_a = p_bV_b$

## Various Speeds of Gas

**2010**

**19. The temperature of an ideal gas is increased from 120K to 480K. If at 120K, the root men square speed of gas molecules is v, then at 480K, it will be**

a) 4v b) 2v c) $\frac{v}{2}$ d) $\frac{v}{4}$

**20. At what temperature of an ideal gas is increased from 120K to 480K. If at 120K, the root mean square speed of gas molecules is v, then at 480K, it will be**

a) 80K b) -73K c) 3K d) 20K

**2008**

**21. The speed of sound in hydrogen at NTP is $1270 ms^{-1}$. Then, the speed in a mixture of hydrogen and oxygen in the ratio 4: 1 by volume will be**

a) $317 ms^{-1}$ b) $635 ms^{-1}$ c) $830 ms^{-1}$ d) $950 ms^{-1}$

**2006**

**22. Assertion (A): The root mean square and most probable speeds of the molecules in a gas are the same.**

**Reason (R): The Maxwell distribution for the speed of molecules in a gas is symmetrical.**

a) Both assertion and reason are true and reason is the correct explanation of assertion.

b) Both assertion and reason are true but reason is not the correct explanation of assertion.

c) Assertion is true but reason is false.

d) Both assertion and reason are false.

**23. The temperature of $H_2$ at which the rms velocity of its molecules is seven times the rms velocity the molecules of nitrogen at 300 K is**

a) 2100K b) 1700 K c) 1350 K d) 1050 K

**24. If at NTP velocity of sound in a gas is $1150 ms^{-1}$, then the rms velocity of gas molecules at NTP is**

a) $1600 ms^{-1}$ b) $1532.19 ms^{-1}$ c) $160 ms^{-1}$ d) zero

**25. When temperature of an ideal gas is increased from $27^0 C$ to $227^0 C$, its rms speed is changed from $400 ms^{-1}$ to $v_s$. The $v_s$ is**

a) $516 ms^{-1}$ b) $450 ms^{-1}$ c) $310 ms^{-1}$ d) $746 ms^{-1}$

## Pressure and Energy of Gas

**2010**

**26. Assertion (A): If a gas container in motion is suddenly stopped, the temperature of the gas rises.**

**Reason (R): The kinetic energy of ordered mechanical motion is converted into kinetic energy of random motion of gas molecules.**

a) Both assertion and reason are true and reason is the correct explanation of assertion.

b) Both assertion and reason are true but reason is not the correct explanation of assertion.

c) Assertion is true but reason is false.

d) Both assertion and reason are false.

**27. The kinetic energy of 1g molecule of a gas at normal temperature and pressure is (R = 8.31 J/mol-K)**

a) $1.3\times10^{2}\,J$ b) $2.7\times10^{2}\,J$ c) $0.56\times10^{4}\,J$ d) $3.4\times10^{3}\,J$

**28. Which one of the following is not an assumption in the kinetic theory of gases?**

a) The volume occupied by the molecules of the gas is negligible.

b) The force of attraction between the molecules is negligible.

c) The collision between molecules are elastic.

d) All molecules have some speed.

**2009**

**29. A sealed container with negligible coefficient of volumetric expansion contains helium (a monoatomic gas). When it is heated from 300K to 600K, the average KE of helium atoms is**

a) Halved b) Unchanged

c) Doubled d) Increased by factor $\sqrt{2}$

**2008**

**30. Two vessels A and B having equal volume contain equal masses of hydrogen in A and helium in B at 300K. Then, mark the correct statement.**

a) The pressure exerted by hydrogen is half to that exerted by helium.

b) The pressure exerted by hydrogen is equal to that exerted by helium.

c) Average KE of the molecule of hydrogen is half the average KE of the molecules of helium.

d) The pressure exerted by hydrogen is twice that exerted by helium.

**2007**

**31. Two cylinders fitted with pistons contain equal amounts of an ideal diatomic gas at 300K. The piston of A is free to move, while that of B is held fixed. The same amount of heat is given to the gas in each cylinder. If the rise in temperature of gas in A is 300K, then rise in temperature of gas in B is**

a) 30K b) 18K c) 50K d) 42K

**2006**

**32. Pressured of an ideal gas is increased by keeping temperature constant. Kinetic energy of molecules _____**

a) Increase b) Decrease

c) No change d) Can't be determined

**2004**

**33. At which of the following temperature would the molecules of gas have twice the average kinetic energy they have at** $20^0C$

a) $40^0C$ b) $80^0C$ c) $586^0C$ d) $313^0C$

## Degrees of Freedom and Specific Heat

**2010**

**34. Mean free path of gas molecule at constant temperature is inversely proportional to**

a) p b) V c) m d) n (number density)

**2009**

**35. At ordinary temperature, the molecules of an ideal gas have only translational and rotational kinetic energies. At high temperatures they may also have vibrational**

**energy. As a result of this at higher temperature** $(C_V =$ **molar heat capacity at constant volume)**

a) $C_V = \frac{3}{2}$ R for a mono atomic gas

b) $C_V > \frac{3}{2}$R for a mono atomic gas

c) $C_V < \frac{5}{2}$R for a diatomic gas

d) $C_V = \frac{5}{2}$ R for a diatomic gas

**2008**

**36. A given mass of a gas is compressed isothermally until its pressure is doubled. It is then allowed to expand adiabatically until its original volume is restored and its pressure is then found to be 0.75 of its initial pressure. The ratio of the specific heat of the gas is approximately**

a) 1.20 b) 1.41 c) 1.67 d) 1.83

**37. Assertion (A): Mean free path a gas molecules varies inversely as density of the gas.**

**Reason (R): Mead free path varies inversely as pressure of the gas.**

a) Both assertion and reason are true and reason is the correct explanation of assertion.

b) Both assertion and reason are true but reason is not the correct explanation of assertion.

c) Assertion is true but reason is false.

d) Both assertion and reason are false.

**2007**

**38. The degrees of freedom of a molecule of a tri-atomic gas are**

a) 2 b) 4 c) 6 d) 8

## Key

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1) **d** | 2) **b** | 3) **b** | 4) **d** | 5) **c** | 6) **d** | 7) **a** | 8) **c** | 9) **d** | 10) **b** |
| 11) **a** | 12) **c** | 13) **b** | 14) **b** | 15) **b** | 16) **a** | 17) **d** | 18) **d** | 19) **b** | 20) **d** |
| 21) **b** | 22) **d** | 23) **d** | 24) **b** | 25) **a** | 26) **a** | 27) **d** | 28) **d** | 29) **c** | 30) **d** |
| 31) **d** | 32) **c** | 33) **d** | 34) **d** | 35) **a** | 36) **b** | 37) **b** | 38) **c** | | |

## Hints

## Gas Law

1. $V \propto T$

Here, $\frac{V_1}{V_2} = \frac{T_1}{T_2}$

$V_1 = V$ then $V_2 = 2V$ and $T_1 = 300K$

$\therefore \frac{1}{2} = \frac{300}{T_2}$

$T_2 = 600K$

$T_2 = 327^0 K$

So, $\Delta t = 327 - 27$

$= 300^0 C$

3. $\left(p + \frac{\mu^2 a}{V^2}\right)(V - \mu b) = \mu RT$

$p = \left(\frac{\mu RT}{V - \mu b}\right) - \frac{\mu^2 a}{V^2}$

Given equation, $p = \left(\frac{RT}{2V - b} - \frac{a}{4b^2}\right)$

On comparing the given equation with this standard equation, we get

$\mu = \frac{1}{2}$ d

Hence, $\mu = \frac{m}{M} \Rightarrow$ mass of gas

$m = \mu M = \frac{1}{2} \times 44 = 22g$

4. $p_{mix} = p_1 + p_2$

$= \frac{\mu_1 RT}{V} + \frac{\mu_2 RT}{V}$

$= \frac{m_1}{M_1} . \frac{RT}{V} + \frac{m_2}{M_2} . \frac{RT}{V}$

$= \frac{8}{32} . \frac{RT}{V} + \frac{7}{28} . \frac{RT}{V} = \frac{RT}{2V}$

$10 = \frac{RT}{2V}$…………………..(i)

When oxygen is absorbed then for nitrogen by pressure

$p = \frac{7}{28} \frac{RT}{V}$

$p = \frac{RT}{4V}$ …………..(ii)

From eqs (i) and (ii) we get

Pressure of the nitrogen p = 5 atm

9. pV = nRT

Or $pV = \frac{m}{M} RT$

Or $\frac{pV}{m} = \frac{1}{M} RT$ or $\frac{p}{\rho} = \frac{RT}{M}$

Or $\frac{\rho}{p} = \frac{1}{T}$

$\therefore \frac{\rho_1 / p_1}{\rho_2 / p_2} = \frac{T_2}{T_1} \Rightarrow \frac{x}{(\rho_2 / p_2)} = \frac{383}{283}$

Or $\frac{\rho_2}{p_2}=\frac{283}{383}x$

10. $\frac{p_1V_1}{T_1}=\frac{p_2V_2}{T_2}$

Or $V_2=\frac{p_1V_1T_2}{p_2T_1}$

$\therefore V_2=\frac{1\times 500\times(273-3)}{0.5\times(273+27)}$

$V_2=\frac{1\times 500\times 270}{0.5\times 300}$

$V_2=900m^3$

13. $\frac{V_1}{V_2}=\frac{T_1}{T_2}$

So, $V_2=\frac{V_1T_2}{T_1}$

$\therefore V_2=1\times\frac{(297+273)}{(27+273)}$

$\Rightarrow V_2=\frac{570}{300}$

$\Rightarrow V_2=1.9L$

16. No. of moles $n=\frac{m}{molecular\ weight}=\frac{5}{32}$

pV = nRT

$\Rightarrow pV=\frac{5}{32}RT$

17. $\frac{p_1V_1}{T_1}=\frac{p_2V_2}{T_2}$

Here $T_1=T_2$

And $p_1=1atm$, $V_1=10cc$, $p_2=4atm$

Now from eq (i) $p_1V_1=P_2V_2$

$10 \times 1 = 4 \times V_2$

$V_2 = 2.5cc$

## Various Speeds of Gas

19. $v_{rms} = \sqrt{\frac{3RT}{M}}$

So, $\frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}}$

Now, $T_1 = 120K$, $T_2 = 480K$, $v_1 = v$

So, $\frac{v_1}{v_2} = \sqrt{\frac{120}{480}} = \sqrt{\frac{1}{4}} = \frac{1}{2}$

$\Rightarrow \frac{v}{v_2} = \frac{1}{2}$

$\Rightarrow v_2 = 2v$

20. $C = \sqrt{\frac{3RT}{M}}$

$\frac{T}{M} = \text{Constant}$

$\frac{T}{2} = \frac{273+47}{32}$

Or $\frac{T}{2} = \frac{320}{32} = 10$

Or T = 20 K

21. Density of mixture $\rho_m = \frac{4V \times 1 + V \times 16}{5V}$

As $v \propto \left(\frac{1}{\rho}\right)^{1/2}$

$\therefore$ Velocity in mixture $= \frac{1270}{(4)^{1/2}} = 635ms^{-1}$

23. $v_{rmp} = \sqrt{\frac{3RT}{m}}$

$\frac{v_1}{v_2} = \sqrt{\frac{T_1}{M_1} \times \frac{M_2}{T_2}}$

$\frac{v_H}{v_N} = \sqrt{\frac{T_H}{M_H} \times \frac{M_N}{T_N}}$

$7 = \sqrt{\frac{T_H \times 28}{2 \times 300}}$

$49 = \frac{T_H \times 28}{600}$

$T_H = \frac{49 \times 600}{28} = 1050K$

24. $R = \frac{8.3}{4.2} cal\ g\ mol^{-1} - K^{-1}$

$C_V = C_P - R = \left(4.8 - \frac{8.3}{4.2}\right) = 2824$

$\gamma = \frac{C_p}{C_v} = \frac{4.8}{2.824} = 1.69$

Since, $v = \sqrt{\left(\frac{3}{\gamma}\right)} v_s = \sqrt{\frac{3}{1.69}} \times 1150 = 1532.19 ms^{-1}$

25. $v_{rms} \propto \sqrt{T}$

Hence, $\frac{v_{rms(1)}}{v_{rms(2)}} \propto \sqrt{\frac{T_1}{T_2}}$

$\frac{400}{v_{rms(2)}} = \frac{\sqrt{27+273}}{\sqrt{227+273}} = \sqrt{\frac{300}{500}}$

$v_{rms(2)} = v = \sqrt{\frac{500}{300}} \times 400 \approx 516 ms^{-1}$

## Pressure and Energy of Gas

27. $E = \frac{f}{2}RT$

$E_{trans} = \frac{3}{2}RT = \frac{3}{2} \times 8.31 \times (273+0) = 3.4 \times 10^3 J$

31. $E = \frac{3}{2}kT$ Or $E \propto T$

$\frac{E_1}{E_2} = \frac{T_1}{T_2}$ Or $\frac{E_1}{2E_1} = \frac{273+20}{T_2}$

Or $T_2 = 2 \times 293 = 586K = 586 - 273 = 313^0 C$

## Degrees of Freedom and Specific Heat

36. $p \propto \frac{1}{V}$

$\Rightarrow \frac{p_2}{p_1} = \frac{V_1}{V_2}$

$\Rightarrow \frac{2p}{p} = \frac{V_1}{V_2}$

$\therefore \frac{V_1}{V_2} = 2$

$pV^{\gamma} =$ Constant

$\frac{p_1}{p_2} = \left(\frac{V_2}{V_1}\right)^{\gamma}$

$\Rightarrow \frac{2p}{0.75p} = \left(\frac{2}{1}\right)^{\gamma}$

$\Rightarrow \log\left(\frac{8}{3}\right) = \gamma \log 2$

$\Rightarrow \log 8 - \log 3 = \gamma \log 2$

$\therefore \gamma = 1.41$